

VLBI Validation Project

W. J. Ross

Deep Space Network Operations

This article summarizes the DSN operations support of the first session of a series of yearly sessions being conducted by the VLBI Validation Project. It covers the period November 1976 through January 1977 wherein two training and three operational experiments were conducted at the Deep Space Communications Complex (DSCC) at Goldstone, California.

I. Introduction

The VLBI (Very Long Baseline Interferometry) Validation Project Task was established in response to a letter of January 2, 1976, from NASA Headquarters. A plan was subsequently developed leading to a comparison of VLBI techniques with laser ranging systems by conducting a series of vector measurements using common benchmark locations at continental distances (Goldstone, Haystack, and the McDonald Observatory) with an accuracy goal on the order of 5 cm.

The major activities included in the Validation Task are:

- (1) An initial measurement of intra-Goldstone baselines and comparing with existing survey data for self-validation.
- (2) An improved measurement of intra-Goldstone baselines to demonstrate short baseline accuracy with advanced system technology and comparison with improved survey to establish an upper bound on error sources.

- (3) Compatibility testing and readiness tests at Goldstone in preparation for long baseline tests.
- (4) Measurement of benchmark locations at Goldstone, McDonald, and Haystack using VLBI advanced systems technology.
- (5) Intercomparison between VLBI and laser measurement at benchmark locations at Goldstone, McDonald, and Haystack.

The operational objectives for the first VLBI Validation Project session were to:

- (1) Demonstrate reliable three station operation by Goldstone Complex personnel.
- (2) Provide project experience to better plan succeeding tests.
- (3) Identify and correct problem areas.

II. Operations

A. Training

The Goldstone Complex operations commenced with two personnel training experiments. For the first experiment, the Radio Science Support Group personnel participated primarily as observers during an OTDA Platform Parameters Source Survey VLBI experiment. For the second training exercise, the same personnel configured the equipment and conducted the experiment under the guidance of experienced JPL Tracking Systems and Applications Section personnel. Configuring the VLBI equipment, and solving hardware and procedural problems, provided excellent training for the Support Group but little data were obtained.

B. Experiments

The training activities were followed by three operational experiments conducted during December 1976 and January 1977. The results were satisfactory in that useful data were acquired during 77 percent of the scheduled experiment periods. The remainder of the time was used to set up, calibrate the system and de-implement the equipment following the experiments.

III. Scheduling

Combinations of the four DSN Goldstone stations (stations 11, 12, 13, and 14) were scheduled for the training exercises and the operational experiments. The experiments were spaced so as to allow time for evaluating the operational performance and equipment problems and taking corrective action prior to the subsequent experiment. Table 1 shows the hours scheduled, the stations involved, and the dates the activities occurred. For the last experiment, time was scheduled to allow the equipment to be installed on a non-interference basis in the station control rooms during the preceding station activity. This was of enough benefit to justify continuing the practice for future VLBI Validation Project experiments.

IV. Personnel

The training and operational experiments were supported by the Radio Science Support Group personnel, the stations' operations crews, and by experienced Tracking Systems and Applications Section personnel who not only acted as instructors and/or monitors of the experiments, but also provided the valuable assistance required to set up and calibrate the configuration at each station.

V. Configuration

The equipment configuration used to support the operational experiments is shown in Fig. 1.

The MK 0 (48-kHz VLBI Data Recording System) was the prime source of data. The MK II Recording Terminal was used primarily to train the supporting personnel for future project activities and therefore the data obtained was not processed.

The Bandwidth Synthesis (BWS) equipment consisted of three separate units; the MK II consisted of six separate units; and the MK 0 consisted of an Analog to Digital (A-D) VLBI Adapter and Signal Coupler connected to the station XDS 920 digital computer. By the last experiment, some of the BWS and MK II units had been installed in small portable cabinets (or modularized), which reduced the complexity of the configuration and helped to reduce the setup time.

All synthesizers used to generate local oscillator (LO) signals were referenced to the station Hydrogen Maser Frequency Standard where available; otherwise, the station Rubidium Frequency Standard was used. The 5-MHz signal for the VLBI receiver local oscillator was obtained from the MK II Recording Terminal distribution system for convenience. The VLBI receivers were located in the station antenna assemblies and obtained the S-band signal from the Travelling Wave Maser via an isolation coupler. The 50-MHz IF signal went via coaxial cable to the attenuator assemblies located in the respective station control rooms.

The F3 signal was 50 MHz, which converted the 50-MHz IF to baseband. F1 and F2 were selected to result in 24-kHz upper and lower sideband signals, which were sequentially sampled and sent to the A-D VLBI adapter connected to the XDS 920 computer for sampling, digitizing, formatting, and recording. The tapes were then sent to Pasadena for correlation and processing.

VI. Problems

Some problems were encountered during setup and during the experiments. Three examples and their solutions are listed below:

- (1) One VLBI receiver local oscillator failed during setup. This unit multiplies the 5 MHz to 2240 MHz to convert the S-band signal (2290 MHz) to the 50-MHz IF. An emergency substitution was made by using the Block III receiver LO chain for this one experiment.

- (2) Both digital tape units failed within a few minutes of each other at one station. The backup XDS 920 computer was then substituted for the remainder of the experiment.
- (3) The 24-kHz signal to the A-D VLBI adapter was found to be too low for satisfactory data recording. This was caused by a 50-ohm input impedance Spectrum Analyzer being inadvertently connected across the high impedance line. The Spectrum Analyzer was disconnected as soon as the cause was discovered.

Other problems which were encountered during the experiments were rapidly corrected.

VII. Summary

The objectives of the first VLBI Validation Project session were met. The Goldstone personnel are better prepared to conduct subsequent project experiments and the equipment has been partially modularized. Permanent installation of the VLBI equipment in control room racks is planned for subsequent project sessions.

Table 1. Training and experiment schedule

Purpose	Date	Time, hours	DSS			
			11	12	13	14
Training	11 November	8	X		X	
Training	29 November	8			X	X
Experiment 1	6 December	12	X		X	X
Experiment 2	29 December	8	X	X		X
Experiment 3	24 January	9	X		X	X

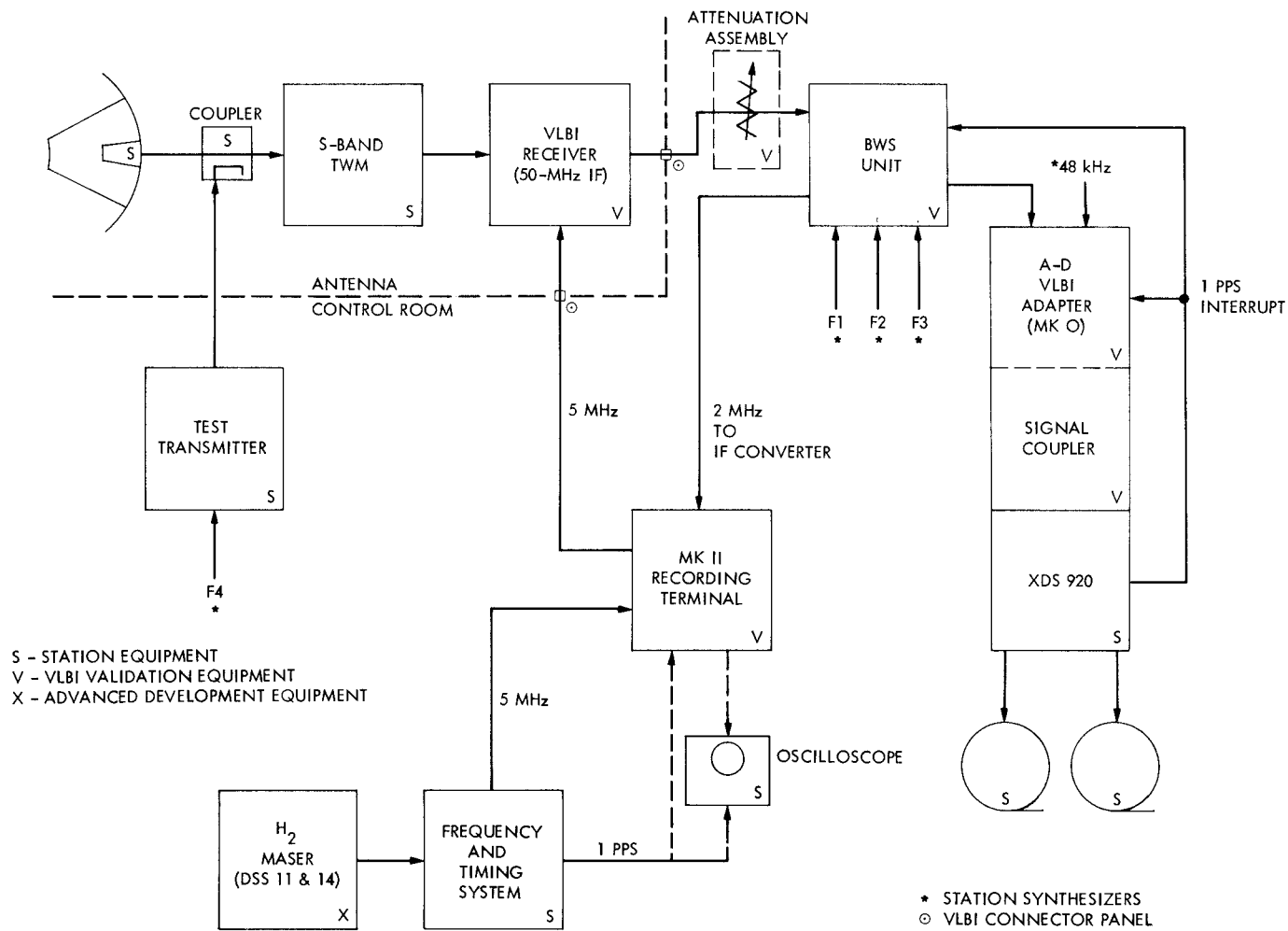


Fig. 1. VLBI Validation Project station configuration for Session 1